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Report No.

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Aerojet-General CORPORATION

AZUSA, CALIFORNIA

INFORMAL REPORT OF PROGRESS

Copy No. 12

12 December 1962

TO: Commanding General
Frankford Arsenal
Philadelphia 37, Pennsylvania

Attention: ORDBA, H. Rosenthal

SUBJECT: Investigation of Stress-Corrosion Cracking of High-Strength Alloys

CONTRACT: DA-04-495-ORD-3069

PERIOD COVERED: 1 October through 31 October 1962

This is the nineteenth in a series of informal progress reports submitted in partial fulfillment of the contract.

AEROJET-GENERAL CORPORATION

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NOTE: The information contained herein is regarded as preliminary and subject to further checking, verification, and analysis.

I. OBJECTIVES

The objectives of the program are outlined below:

A. To investigate the stress-corrosion cracking characteristics of at least three new high-strength alloys of interest for rocket motor case applications. These alloys are 6Al-4V titanium, 18% nickel maraging steel, and 20% nickel maraging steel, in addition to limited testing of vacuum-melted 9 Ni-4 Co steel.

B. To study the environmental parameters that could affect the rate and extent of stress-corrosion cracking.

C. To determine the effect of material parameters (composition, strength level, welding, and microstructure) on stress-corrosion susceptibility.

D. To continue the evaluation of protective coatings and other techniques for preventing stress-corrosion cracking.

II. SUMMARY

The third year's program is in progress with specimens of titanium 6Al-4V alloy under test. The 20% nickel maraging steel specimens are being machined, and the 18% nickel maraging steel material, as well as Republic's 9 Ni-4 Co alloy, are scheduled for delivery within two weeks.

III. WORK PROGRESS

The work program in progress is designed to investigate the stress-corrosion susceptibility of 6Al-4V titanium, 18 and 20% nickel maraging steels, and a Republic Steel Corp. 9% Ni-4% Co alloy. The master program chart is shown in Table 1. Work progress during this report period is shown below.

A. 6Al-4V TITANIUM

This alloy is now under test with both center-notched tensile specimens and bent-beam specimens being evaluated. The warpage of specimens during heat treatment, which was experienced in the past, was avoided by the use of a special fixture fabricated to hold the specimens in a flat position during the aging heat-treat cycle. Machining of specimens after heat treatment, to remove the oxide scale, was found to be essential to the attainment of valid mechanical properties.

B. 20% NICKEL MARAGING STEEL

Two of the 20% nickel materials, annealed and 75% cold-worked, have been received from the manufacturer (Allegheny Ludlum) and are now being machined into specimens. Shipment of the 50% cold-worked material has been delayed because of a mill error in its formulation which required the preparation of a new heat.

C. 18% NICKEL MARAGING STEEL

This alloy has not yet been received but shipment has been promised for early December. One shipment from Republic Steel Corp. will include 0% and 50% cold-worked material with low titanium content (0.3 to 0.6%). Another shipment from Allegheny Ludlum will contain a high percentage of titanium (0.6 to 1.0%). (The titanium content for this alloy is known to have a marked effect on its mechanical properties.)

D. REPUBLIC'S 9% NI-4% CO ALLOY

This alloy is due to be shipped early in December. Material with two different percentages of carbon will be received (0.25 to 0.30% C and 0.40 to 0.45% C).

The evaluation of protective coatings to prevent stress-corrosion cracking is continuing and will be conducted throughout the program. This evaluation is based upon the testing of the latest coating systems developed by various manufacturers. Coatings are being applied to H-11 steel (which was found to be highly susceptible to stress-corrosion cracking in earlier tests), and specimens of this alloy are being tested by deflection in beam fixtures after coating. This manner of testing is designed to evaluate the integrity of the coating when subjected to stretching. Both barrier-type and sacrificial-type coatings are under evaluation, including epoxy, vinyl, polyurethane, zinc, and zinc silicate based systems. The next quarterly progress report will contain the results of the coating program to that date.

IV. FUTURE WORK

Testing of titanium 6Al-4V alloy will continue. Welded samples of this material are also being prepared for testing. The maraging steels will be under test within the next 6 weeks if promised delivery dates are maintained. The protective coating evaluation will continue.

TABLE 1

Third-Year Program

Alloy	Anticipated 0.2% Yield Strength*	Possible Heat Treatment	Test Method	Code	Distilled Water (-01)	Water (-02)	3% NaCl (-03)	Sodium Dichromate Solution (-04)	Soluble Oil (-05)	High Humidity (-06)	Trichloro-ethylene (-07)	Cosmoline (-08)	Solid Propellant (-09)	Air (-10)	Sea Coast Exposure (-11)
6Al-4V Titanium	135,000	As received, annealed	Bent Beam	G-1-B	3**	3	3	3	3	3	-	3	3	3	3
			U-Bend	G-1-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	G-1-C	2	-	2	2	2	-	-	-	-	2	-
	170,000	1650°F WQ and 900°F age	Bent Beam	G-2-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	G-2-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	G-2-C	2	-	2	2	2	-	-	-	-	2	-
	110,000	Welded, 900°F age	Bent Beam	G-W-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	G-W-U	-	-	-	-	-	3	3	-	-	-	3
20-Nickel Maraging Steel	250,000	Solution anneal -100°F, 850°F age	Bent Beam	H-1-B	3	3	3	3	3	3		3	3	3	3
			U-Bend	H-1-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	H-1-C	2		2	2	2	-	-	-	-	2	-
	275,000	50% CW 850°F age	Bent Beam	H-2-B	3	3	3	3	3	3		3	3	3	3
			U-Bend	H-2-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	H-2-C	2	-	2	2	2	-	-	-	-	2	-
	300,000	75% CW 850°F age	Bent Beam	H-3-B	3	3	3	3	3	3		3	3	3	3
			U-Bend	H-3-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	H-3-C	2	-	2	2	2	-	-	-	-	2	-
	250,000	Welded	Bent Beam	H-W-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	H-W-U	-	-	-	-	-	3	3	-	-	-	3
18-NiMoCo Maraging Steel	270,000	0% CW 0.3/0.6 % Ti Aged at 900°F	Bent Beam	I-1-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	I-1-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	I-1-C	2		2	2	2	-	-	-	-	2	-
	300,000	50% CW 0.3/0.6% Ti Aged at 900°F	Bent Beam	I-2-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	I-2-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	I-2-C	2	-	2	2	2	-	-	-	-	2	
	320,000	50% CW 0.6/1.0% Ti Aged at 900°F	Bent Beam	I-3-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	I-3-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	I-3-C	2	-	2	2	2	-	-	-	-	2	
	No data on hand	0.3/0.6% Ti Welded	Bent Beam	I-W-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	I-W-U	-	-	-	-	-	3	3	-	-	-	3
9Ni-4Co Vacuum-Cast Alloy	No data on hand	Aged 0.25%/0.30% C	Bent Beam	J-I-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	J-I-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	J-I-C	2		2	2	2	-	-	-	-	2	
	No data on hand	Aged 0.40/0.45% C	Bent Beam	J-2-B	3	3	3	3	3	3	-	3	3	3	3
			U-Bend	J-2-U	-	-	-	-	-	3	3	-	-	-	3
			Center Notch	J-2-C	2	-	2	2	2	-	-	-	-	2	-

*Based on suppliers' bulletins and/or previous Aerojet data.

**Number refers to number of tests.